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HOW TO FIND CELESTIAL OBJECTS WITH AN EQUATORIAL TELESCOPE WITHOUT THE AID OF A SIDEREAL TIME-PIECE.

By Charles Burckhalter.

About nine years ago, when a most enthusiastic student of astronomy, I devised a method which is both simple and efficient for finding invisible, or, to me, unknown objects with an equatorial telescope without the aid of a sidereal time-piece. Having never seen this or any similar method in print, I then believed it to be new, but, as it will be useful to many members of this Society who have equatorials but are without sidereal time-keepers, I will briefly, and as simply as possible, describe the method. By a few trials it will become so familiar that sidereal time is quite unnecessary when we merely wish to find some object whose right ascension and declination are known—in fact, I use it to this day at the Chabot Observatory, rather than go to the trouble of going down a long flight of stairs and carrying up the chronometer, using the sky instead.

At the time of which I write, I found myself the happy possessor of a very fair 4-inch alt-azimuth telescope, which I immediately converted with my own hands into an equatorial without driving-clock or circles—the first equatorial mounting I had ever seen. I had provided myself with "Burritt's Geography of the Heavens" and that invaluable little book "Webb's Celestial Objects for Common Telescopes" (a number of copies of both may be found in the Society's library) and I enthusiastically resolved to carefully observe every object mentioned within the power of my telescope. But, alas! I found that to "resolve" was one thing, and to *find* the objects was quite another.

For prominent financial reasons I did not provide myself with a transit and clock, and my text-book star-maps were found to be practically useless, and, no matter how hard I tried to deceive myself, I was plainly in a dilemma. However, the stars appeared to wink at me as kindly as ever, and I soon found a way out of the difficulty. Hour and declination circles were a necessity, and, as I could not afford to have them made, I determined to construct a pair of circles myself. My first circles were very rude; they were made of stiff card-board; and, while they could not claim relationship to the elaborate affairs we find with well-mounted equatorials, they placed the sky at my command, and no circles could do more.

I first marked off an 8-inch declination circle, which I carefully divided into single degrees, the space between marks being about one-fifteenth of an inch; every fifth degree was represented by a longer mark, and every tenth degree by a mark with a dot at the end toward the center of the circle. The time-circle was divided in the same manner, each division corresponding to four minutes of time, the twenty-minute and the hour-marks being drawn and marked with greater prominence. These were attached to the bearings carrying the polar and declination axes, and a "pointer" was attached to each of the axes.

I will now give a few examples of how to use the circles, using only well-known and easy objects—the easier the better, in the firm belief that anything new to the beginner cannot be too plainly described.

For our first example we shall take the great nebula in *Orion*. Of course we can find this well-known object without any aid whatever, but it is just as good for our first illustration as though it were the most difficult object to find in the sky. Having determined that this is the object we wish to find, we refer to "WEBB'S Celestial Objects" and find its right ascension to be 5^h 29^m and the declination 5° 28′ south. We next take some well-known object *near by*, let us say *Rigel*, and we find that WEBB gives the R. A. as 5^h 9^m and the declination as 8° 20′ south. A little sum in arithmetic will show us that the great nebula is 2° 52′ *north* and twenty minutes *east* of *Rigel*, and this is all we need to know.

Now, employing a low power eye-piece, we point the telescope to *Rigel*. For the first few trials it may be advisable to use a common watch, but this will soon become unnecessary. Having pointed the telescope to *Rigel*, when he is in the center of the field, we read the face of our watch, say ten minutes past eight, and we will allow ourselves one minute to point our telescope to the great nebula. First we move our telescope by the circle nineteen minutes east (for we must *subtract* the minute we shall use in making the pointing when the object is to the *east*) and, by the declination circle we move the telescope 2° 52′ *north* as nearly as possible, and at the end of the minute, or at eleven minutes past eight, the great nebula will be in the center of the field. Refraction may be ignored entirely since our starting point and the object we wish to find are always near each other.

For our next example we will take "HIND's Crimson Star" in *Lepus*, which is in the same neighborhood and we can again use *Rigel* for our starting point. This star is invisible without a telescope, but is readily recognized when found, and therefore is a good object for first trials. WEBB gives its position as R. A. $4^h\ 54^m$ and south declination 14° 59′—say fifteen degrees, and refering to our position of *Rigel*, we find the star is fifteen minutes west and 6° 40′ south of *Rigel*. First set on *Rigel*, then, allowing one minute, as before, to point the telescope, observing however that when the object is *west* of our starting point, we must *add* the minute, on account of the westerly motion of the object, we move the telescope *sixteen* minutes west and 6° 40′ south and the telescope is pointed directly to the position the star will occupy at the end of the minute.

It is often desirable to observe a star or planet in the daytime, and we can readily do this by taking the sun as our starting point, but as the sun changes his right ascension about four minutes every day, and the planets, especially *Venus* and *Mercury*, show great changes from day to day, we must have access to a nautical almanac, and we must not only know their positions for that day, but approximately for the hour in which we wish to observe them. These positions are readily found, however, in the almanac, and with the exception of a little more trouble, are quite as good starting-points as our first examples, always working of course from the sun's center.

The method is not yet exhausted however, for, by reversing the order of the first two examples, we can with certainty approximately fix the position of any object whose place we wish to remember. Suppose, for example, we find an object we wish to "lay by for future reference" and desire to fix its position. First, when the object is in the center of the field (a high power eye-piece may be advantageously employed) we read the face of our watch and record the time; then read and *record* the readings of our circles, then point the telescope to some well-known neighboring object and when we have it in the center of the field, again note the time by our watch, and then at our leisure again read the circles. The difference of the two sets of circle readings, plus or minus the interval that elapsed between the two readings of our watch, will give us the position of the object reckoning from the well-known adjacent object to which we last pointed the telescope.

I will illustrate this by an example. Suppose we find an object which we wish to observe at a future time, and that when the object is in the center of the field, we record the time indicated by our watch, say ten o'clock. Then we read the circles and record the readings. Next we point the telescope to some neighboring bright star—(say *Sirius*,) and when he is in the center of the field again read the watch, and let us assume that it is now two minutes past ten, and again read off the difference in the positions of the object and *Sirius*, and let us say the object was twenty degrees north and one hour and ten minutes east. Now, as *Sirius* is in R. A. 6^h 40^m, the object *must* be in R. A. 7^h 50^m if we take no account of the time interval of two minutes which we occupied in reading the circles, but this must receive attention, and as the object was *east* of *Sirius* and moving *westward*, the two minutes must be subtracted and the corrected position is R. A. 7^h 48^m. As our object was 20° north of *Sirius* and the declination of *Sirius* is 16° 33′ south, we have only to subtract 16° 33′ from 20° and we at once have the declination of the object, which is 3° 27′ north.

I have assumed in the above examples that the telescope was without a driving-clock, but if a clock can be used it is much easier, for while we have the telescope clamped upon the star which we shall take for a starting point, we set the telescope in declination, and then we have only to allow for the time occupied in moving in right ascension, and as this usually takes but a few seconds with small telescopes, we may as a rule, ignore the question of time altogether.

I will add for the benefit of any who may wish to construct a pair of circles as above described, that it is not all necessary to have them adjusted with extreme accuracy as is the case when sidereal time is employed, for we do not work from the *meridian*, but to or from our neighboring known object. The known object should always be in the vicinity of the one whose place is to be ascertained, in order that the small errors in the adjustment of the polar axis, and the eccentricity of the circles may be rendered practically insensible by being nearly the same for both objects.